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Urban benzene and population exposure

People aren't just at risk from carcinogenic benzene when they are out on city streets.

Benzene pollution emanating from motor traffic can cause leukaemia[1-3], with the risk being estimated at about four cases per million among people who experience lifelong exposure to benzene concentrations of 1 μg m^{-3} in air[4-6]. But we show here that personal exposure, and therefore risk estimates, cannot simply be estimated from environmental concentrations of benzene. Using a new sampling device that monitors both of these parameters, we have discovered that people living in different European cities are exposed to concentrations of benzene that may be twice as high as the urban average.

We have monitored benzene pollution in each of the European towns of Antwerp, Athens, Copenhagen, Murcia, Padua and Rouen at 100 sampling sites distributed over a multiscale grid drawn on the town map[7]. Every two months (from September 1997 to September 1998), these sites were tested from Monday morning to Friday afternoon by using a radial symmetry passive sampler device (termed a *radiello*[8]).

This device relies on the diffusion of gas molecules as a result of a concentration gradient across a diffusive barrier: diffusing molecules are captured by an adsorbing material that has a constant benzene-uptake rate of 80×10^{-6} μg min^{-1} for each 1 μg m^{-3} present in air. Concentrations are calculated from the amount collected and the exposure time. Having tested the sampler reliability both in a standard atmosphere chamber and at the actual sampling sites, we found a maximum bias value of 4.45% and a coefficient of variation of 2.5–22.0% for 120 samplers exposed for 4.5 days to benzene concentrations of 1.5–47 μg m^{-3}.

We monitored 50 volunteers and their homes in each town. These volunteers were non-smokers and were equally represented by people exposed to traffic fumes as part of their jobs (police, postal workers, street sweepers, stall-holders, and bus and taxi drivers) and by non-exposed people (students, teachers and clerks), who all wore the sampler from Monday morning to Friday afternoon.

The results (Fig. 1) were derived from 6,205 measurements, of which 50.7, 25.1 and 24.2% represent environmental, personal and home exposure records, respectively. The urban pollution level, presented as the annual average, is seen to increase in European towns from north to south (Fig. 1a): this may be explained by a difference in prevailing meteorological conditions, such as local wind speeds (Fig. 1b).

However, personal exposure data and measurements taken inside homes do not reflect this difference in urban pollution between northern and southern European towns: except in Athens, the population exposure exceeds the average urban concentration and is higher indoors than outdoors (Fig. 1c).

This surprising finding may be explained by the hourly benzene concentration oscillating between very low values during the night and very high values during the middle of the day and the evening.

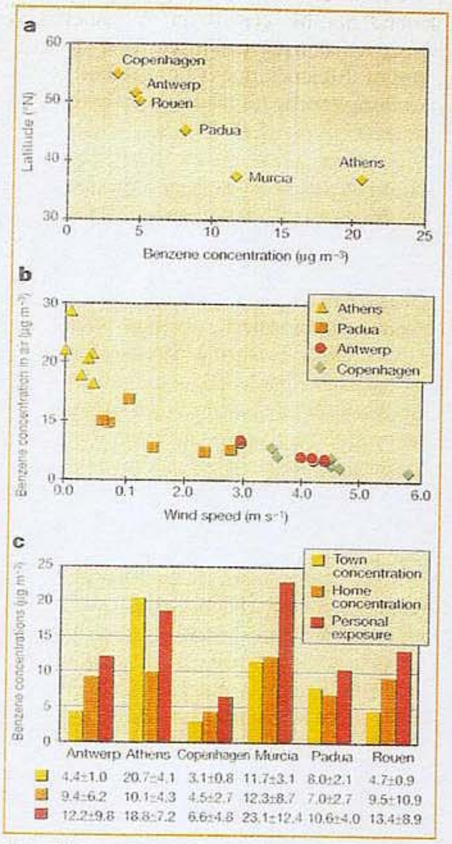

Figure 1 Benzene personal exposure level cannot be calculated as a time-weighted average of outdoor and indoor mean concentrations owing to large hourly urban pollution oscillations. **a,** Benzene urban pollution seems to increase from northern to southern European towns. **b,** This observation may be explained by differences in wind speeds, and therefore ventilation, clearing benzene pollution at different rates in northern and southern towns. In estimating the local population exposure, the reduction in the pollution of northern compared with southern towns is balanced by an opposite trend in indoor pollution. **c,** Population exposure depends on both outdoor and indoor pollution. Measurements using the *radiello* device show that personal exposure is, on average, twice the mean urban pollution level. Annual values for benzene concentrations, presented as averages from six monitoring campaigns, in the street and home and the resulting personal exposure are shown. Values are average concentrations in μg m^{-3}, with 95% confidence intervals.

As most people are about in the streets when the benzene concentration is higher than the daily average, then their actual exposure when out of doors is higher than the value calculated from the daily urban average benzene concentration and the time spent outdoors.

But this outdoor exposure represents only a fraction of the total: as people spend on average 59.1% of their day at home, the contribution from indoor exposure is important. In the European towns studied here, the average pollution level at home turns out to be 1.51 times the outdoor street level, with the exception of Athens, where volunteers live far from the town centre.

The value of the domestic-to-urban pollution ratio rises from southern to northern Europe. This tendency evens out the difference in the level of personal exposure and the level of urban pollution: when no longer exposed out of doors, people are subject to indoor pollution, which is worse in Antwerp, Rouen and Copenhagen, comparable in Padua and Murcia, and better in Athens.

To explain these findings, we suggest that pollution indoors is caused by benzene entering from the streets outside, as shown by the good fit of respective seasonal trends (data not shown). The pollution indoors is generally higher than outdoors, possibly because of an imbalance between the flow of pollutant from outside and its removal from inside to outside. In other words, the house itself could be acting as a flywheel created by adsorbent surfaces on walls, floors and furnishings. This idea is supported by the lower indoor pollution in southern European towns: in northern European houses, carpets, linoleum and wood surfaces are favoured, whereas tiling, marble and bare walls are typically used in southern Europe.

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